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May 19, 2000

**Box PATENT APPLICATION**

Commissioner for Patents  
Washington, D.C. 20231

Re: New U.S. Patent Appln.  
Our Ref: 225/48876

Sir:

Transmitted herewith for filing is the patent application of:  
**Christian GOERIGK et al.**

entitled:

**EXHAUST-GAS CLEANING SYSTEM WITH NITROGEN OXIDE  
REDUCTION AND WITH THE ADDITION OF REDUCING AGENT**

Enclosed are:

1. Specification, including 9 claims (12 pages).
2. 1 Sheet of x Formal \_\_\_\_\_ Informal drawings showing Figs. 1 - 3.
3. X Declaration and Power of Attorney (**unexecuted**).
4. Priority is being claimed under 35 U.S.C. §119 and 37 C.F.R. §1.55 based on priority document 199 229 59.7 filed in Germany on May 19, 1999.
5. X Information Disclosure Statement.
6. The filing fee has been calculated as shown below:

|                                    |                 |                    |                 |
|------------------------------------|-----------------|--------------------|-----------------|
| Basic Fee                          |                 | \$345/690 =        | \$690.00        |
| Total Claims                       | <u>9</u> - 20 = | <u>x</u> \$ 9/18 = | \$              |
| Independent Claims                 | <u>2</u> - 3 =  | <u>x</u> \$39/78 = | \$              |
| Multiple Dependent Claim Presented |                 | \$130/260 =        | \$              |
| Total Filing Fee                   |                 |                    | <u>\$690.00</u> |

The filing fee is being deferred.

The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment, to Deposit Account No. 05-1323 (Docket #225/48876). A duplicate copy of this sheet is enclosed.

Respectfully submitted,

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EXHAUST-GAS CLEANING SYSTEM WITH NITROGEN OXIDE REDUCTION AND  
WITH THE ADDITION OF REDUCING AGENT

BACKGROUND AND SUMMARY OF INVENTION

This application claims the priority of German patent document 199 22 959.7, filed May 19, 1999, the disclosure of which is expressly incorporated by reference herein.

5       The invention relates to an exhaust-gas cleaning system. Exhaust-gas cleaning systems are used, for example, for internal-combustion engines of motor vehicles and enable any nitrogen oxides contained in the exhaust gas to be cleaned out using the so-called SCR (Selective Catalytic Reduction) process. In this process, the nitrogen oxides are chemically reduced in a suitable reduction catalytic converter with the participation of a suitable reducing agent which is added to the exhaust-gas flow. Ammonia in vapour or gas form is often used as the reducing agent and is generated by the vaporization and subsequent thermolysis and hydrolysis of urea which has preferably been introduced into the exhaust-gas flow in solution.

20       An exhaust-gas cleaning system of this type is disclosed in publication WO 97/36676. In this system, liquid urea solution is vaporized in an electrically heatable metering unit, which is arranged on an exhaust pipe wall, with the urea being hydrolysed and is injected into the exhaust-gas flow. A downstream mixer assists with mixing the injected reducing agent with the exhaust gas.

25       EP 0,555,746 B1 discloses a metal honeycomb vaporizer, which is heated by the exhaust gas and serves simultaneously

as a hydrolysis catalytic converter for injected urea solution  
and a flow mixer. Downstream of the metal honeycomb vaporizer  
body in the exhaust system there is a multipart catalytic  
converter unit which comprises an upstream nitrogen oxide  
5 reduction catalytic converter and a downstream oxidation  
catalytic converter.

In an exhaust-gas cleaning system which is disclosed in  
10 Patent EP 0,615,777 B1, urea is injected into the exhaust-gas  
flow in the form of solid particles, which is then fed to a  
hydrolysis catalytic converter and, from there, to a nitrogen  
oxide reduction catalytic converter and a downstream oxidation  
catalytic converter.

The invention is based on the technical problem of  
providing an exhaust-gas cleaning system in which the reducing  
agent can be added to the exhaust-gas flow as a vapour in an  
advantageous manner and with relatively little outlay for the  
purpose of nitrogen oxide reduction.

20 The exhaust-gas cleaning system of the present invention  
solves this problem. In the system according to the present  
invention, the vaporizer which is arranged in the exhaust  
system upstream of the nitrogen oxide reduction catalytic  
25 converter contains, as its heat source, either a heatable  
deflector surface, onto which the reducing agent, which is  
supplied by a feed unit, is directed under pressure, or a  
microwave generator. It has been found that, firstly it is  
possible to achieve sufficient vaporization of the reducing  
30 agent and, secondly, the cost of providing the vaporizer  
remains relatively low.

In an embodiment of the exhaust-gas cleaning system, the heat source provided for the vaporizer is a baffle plate which is oriented parallel to the direction of flow of the exhaust gas and therefore does not significantly disrupt the  
5 exhaust-gas flow, so that there is no significant drop in the exhaust-gas pressure across the vaporizer. The baffle plate may be positioned with surface-to-surface contact against the inside of an exhaust pipe or may be positioned in the interior of the latter. The heating may be effected in a conventional  
10 way which is suitable for the particular application, for example by means of an associated electrical heater unit.

15 In another embodiment of the exhaust-gas cleaning system, the heat source provided for the vaporizer is a heatable baffle plate which is situated in a part-flow branch line of the exhaust system, this branch line branching off from a main-flow exhaust system section and opening back into this section downstream of the branching point.

20 Another embodiment of the exhaust-gas cleaning system contains at least two catalytic converter stages which are connected one behind the other, having different ammonia storage performances and at least one of which forms the nitrogen oxide reduction catalytic converter. It has been  
25 found that in certain cases this measure is advantageous in order to achieve the maximum possible reduction of nitrogen oxide, and, depending on the particular application, the upstream stage may have a higher or lower ammonia storage capacity than the downstream stage.

30

Other objects, advantages and novel features of the present invention will become apparent from the following

detailed description of the invention when considered in conjunction with the accompanying drawings.

**BRIEF DESCRIPTION OF THE DRAWINGS**

5 Fig. 1 shows a diagrammatic block diagram of an internal-combustion engine with an exhaust-gas cleaning system having a microwave generator vaporizer;

10 Fig. 2 shows an illustration corresponding to Fig. 1, but with an exhaust-gas cleaning system having a baffle-plate vaporizer lying in the exhaust-gas main flow; and

15 Fig. 3 shows an illustration corresponding to Fig. 1, but with an exhaust-gas system having a baffle-plate vaporizer arranged in a part-flow branch line.

**DETAILED DESCRIPTION OF THE DRAWINGS**

20 Fig. 1 diagrammatically depicts an internal-combustion engine 1 which is used, for example, in a motor vehicle and has an associated exhaust-gas cleaning system for cleaning the engine exhaust gas, in particular for removing nitrogen oxides which may be contained therein. The nitrogen oxides are produced in particular when internal-combustion engines run in lean mode.

25 To clean nitrogen oxides out of the exhaust gas, the exhaust-gas cleaning system contains a nitrogen oxide reduction catalytic converter 3 which is positioned in the exhaust system 2 of the internal-combustion engine 1. This converter may be of single-stage or multistage design, Fig. 1 illustrating, by way of example, a two-stage design with an upstream stage 3a and a downstream stage 3b. The ammonia storage capacity of the two catalytic converter stages 3a, 3b

preferably differs, in which case the upstream catalytic converter stage 3a has a lower or higher ammonia storage capacity than the downstream catalytic converter stage 3b, as required.

5

Furthermore, upstream of the nitrogen oxide reduction catalytic converter 3, the exhaust-gas cleaning system contains, in the exhaust system 2, a reducing-agent metering device which has a feed unit 4 and a vaporizer 5. By means of  
10 the feed unit 4, a reducing agent or a precursor thereof (e.g., solid or liquid urea) is injected from the outside into the single-part exhaust system 2, in which the exhaust-gas flow 6 which has been collected and comes from the individual engine cylinders is guided. The vaporizer 5 is positioned downstream of the metering point in the exhaust system 2 and contains, as its heat source, a microwave generator, which is of a standard type and therefore is not explained further here. Under the action of the microwave radiation generated by the microwave generator, injected urea is hydrolysed in the vaporizer 5 to form gaseous ammonia and carbon dioxide. To assist with the hydrolysis reaction, the vaporizer 5 may contain a suitable hydrolysis catalyst.  
15  
20  
25

In the exhaust system section between the vaporizer 5 and the nitrogen oxide reduction catalytic converter 3, there is a gas mixer 7 of standard design, by means of which the reducing agent which has been vaporized in the vaporizer 5 is mixed homogeneously with the exhaust gas which is to be cleaned. In addition, where necessary the gas mixer 7 may be designed in  
30 such a way that it additionally functions as a urea hydrolysis catalytic converter and/or has a nitrogen-oxide-reducing function. Then, in the subsequent nitrogen oxide reduction catalytic converter 3, the complete selective chemical

reduction of the nitrogen oxides contained in the exhaust gas to form nitrogen takes place with the participation of the reducing agent which is in vapour form.

5       Depending on requirements, it is additionally possible for further catalytic converters with the function of cleaning the exhaust gas, such as an oxidation catalytic converter or a three-way catalytic converter, to be arranged in series upstream or downstream of the nitrogen oxide reduction 10 catalytic converter 3, either as independent catalytic converter bodies or integrated with the nitrogen oxide reduction catalytic converter 3 in a common catalytic converter unit.

15       Fig. 2 shows a variant of the exhaust-gas cleaning system from Fig. 1, the same reference numerals being used for functionally identical components as those in Fig. 1, for the sake of simplicity, and to this extent reference may be made to the above description of Fig. 1. Instead of the microwave vaporizer 5 of the system shown in Fig. 1, the exhaust-gas 20 cleaning system shown in Fig. 2 has a baffle-plate vaporizer, which comprises a heatable baffle plate 5a which is heated in a standard way, which is therefore not shown in more detail, for example electrically.

25       The vaporizing baffle plate 5a is situated in the interior of the single-part exhaust system 2, which is formed by a corresponding exhaust pipe, at a distance from the pipe wall, and is oriented parallel to the longitudinal axis of the 30 exhaust pipe section. Accordingly, the plane of this plate also lies parallel to the main direction of flow of the exhaust-gas flow 6 flowing around it, so that its narrow side

has only a minimal effect on the cross section of flow of the exhaust pipe.

The reducing-agent feed unit 4, which is designed as an  
5 injection unit or injection nozzle and is fitted into an associated opening in the exhaust pipe, lies opposite to and at a distance from the impact side of the baffle plate 5a. Via the injection unit 4, the reducing agent or the reducing-agent precursor, such as dissolved urea, is sprayed under pressure  
10 onto that side of the heated baffle plate 5a which faces it and as a result is vaporized into the exhaust-gas flow 6. The downstream gas mixer 7 ensures that the vaporized reducing agent or reducing-agent precursor is sufficiently mixed with the exhaust gas. In addition, if necessary, the gas mixer 7 may again fulfil the additional function of converting a reducing-agent precursor which has been metered into the exhaust gas in vapour form into the desired reducing agent, for example of converting urea vapour into gaseous ammonia by hydrolysis. In addition, if necessary, the baffle plate 5a may be provided with a catalytically active coating, for example with a hydrolysis catalyst for converting urea into ammonia.  
15 Otherwise, the same advantageous properties and possible modifications as listed above for the system shown in Fig. 1 also apply to the system shown in Fig. 2.

25

Fig. 3 shows a variant of the exhaust-gas cleaning system from Fig. 2, in which, instead of the baffle-plate vaporizer 5a arranged in the exhaust-gas main flow as in the system shown in Fig. 2, a vaporizer, which is again designed as a  
30 heatable baffle plate 5b, is arranged in a part-flow branch line 2a of the exhaust system 2. At an outlet point 8, the part-flow branch line 2a branches off from the main-flow exhaust system section 2b of the exhaust system 2 and, at a

downstream inlet point 9, opens back into the main-flow exhaust system section 2b. Accordingly, in this area, the exhaust-gas flow is divided into a main exhaust-gas flow 6b, which remains in the main-flow exhaust system section 2b and contains most of the exhaust gas, and a partial exhaust-gas flow 6a, which flows through the part-flow branch line 2a and contains less exhaust gas.

In the part-flow branch line 2a, the heatable baffle plate 5b is arranged on a wall of the associated pipe, while the reducing-agent feed unit 4, which is designed as an injection nozzle, is fixed in an opening in the opposite pipe wall area. The injection nozzle 4 in this way lies opposite to and at a distance from the heatable baffle plate 5b and, in operation, sprays the reducing agent or reducing-agent precursor with which it has been supplied, under pressure, onto the facing, hot side of the baffle plate 5b. As a result, the reducing agent or reducing-agent precursor is vaporized and is entrained by the partial exhaust-gas flow 6a, with which it is then combined with the main exhaust-gas flow 6b which bypasses the baffle-plate vaporizer 5b. In the downstream gas mixer 7, the vaporized reducing agent or reducing-agent precursor is mixed homogeneously with the exhaust gas over the entire exhaust pipe cross section and, in the process, if a reducing-agent precursor is involved, is at the same time converted into the desired reducing agent, which is then available for the reduction of nitrogen oxides in the downstream nitrogen oxide reducing-agent catalytic converter 3. Otherwise, the same properties, advantages and possible variations as those indicated above with reference to the systems shown in Figs. 1 and 2 also apply to the system shown in Fig. 3.

The foregoing disclosure has been set forth merely to illustrate the invention and is not intended to be limiting. Since modifications of the disclosed embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed to include everything within the scope of the appended claims and equivalents thereof.

WHAT IS CLAIMED IS:

1. An exhaust-gas cleaning system, comprising:  
a nitrogen oxide reduction catalytic converter for  
reducing nitrogen oxides contained in an exhaust gas;

5           a reducing-agent metering device for metered addition of  
the reducing agent or a reducing-agent precursor to the  
exhaust gas,

wherein said reducing-agent metering device comprises:

10           a feed unit;  
a vaporizer arranged upstream of the  
nitrogen oxide reduction catalytic converter; and  
a heat source selected from the group consisting of a  
heatable deflector surface onto which the reducing agent is  
directed under pressure and a microwave generator.

15           2. An exhaust-gas cleaning system according to  
Claim 1, wherein the heatable deflector surface comprises a  
baffle plate that is oriented parallel to a direction of flow of  
the exhaust gas.

20           3. An exhaust-gas cleaning system according to  
Claim 2, wherein a surface of the baffle plate is arranged  
against an inside surface of a pipe of the exhaust-gas cleaning  
system or is arranged in an interior of the pipe.

25           4. An exhaust-gas cleaning system according to Claim 2,  
wherein the heatable baffle plate is arranged in a part-flow  
branch line of the exhaust-gas cleaning system that branches off  
from a main-flow exhaust system section at a branching point and  
30          opens back into the main-flow exhaust system section downstream  
of the branching point.

5. An exhaust-gas cleaning system according to Claim 1,  
further comprising two catalytic converter stages connected in  
series, wherein each catalytic converter stage has a different  
reducing-agent storage capacity and wherein at least one of the  
5 catalytic converter stages forms the nitrogen oxide reduction  
catalytic converter.

6. A motor vehicle internal combustion engine comprising  
the exhaust-gas cleaning system according to Claim 1.

10 7. A method for cleaning exhaust gas, comprising:

15 guiding an exhaust gas containing nitrogen oxides through a  
main flow channel;

20 injecting a reducing agent into the exhaust gas;

vaporizing the reducing agent;

mixing the vaporized reducing agent and the exhaust gas;

catalytically reducing the nitrogen oxides,

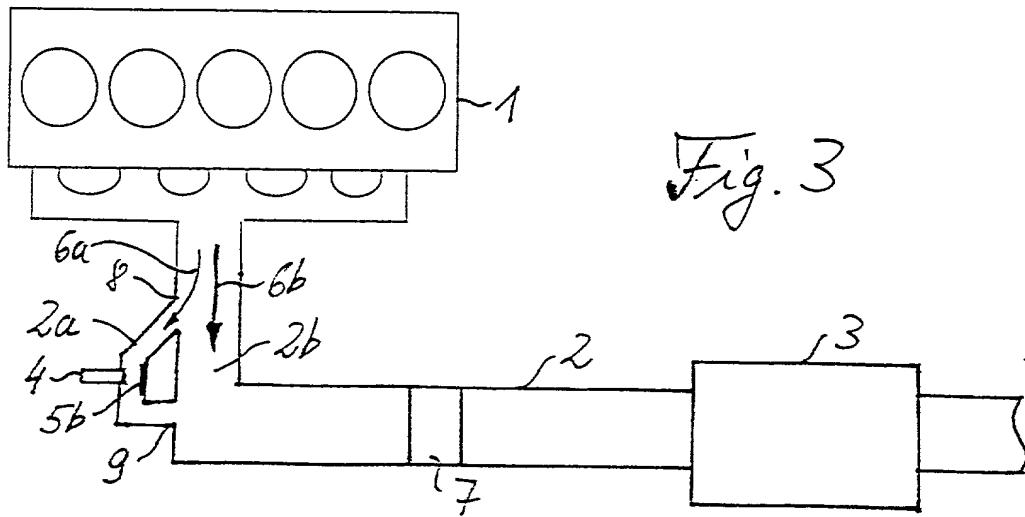
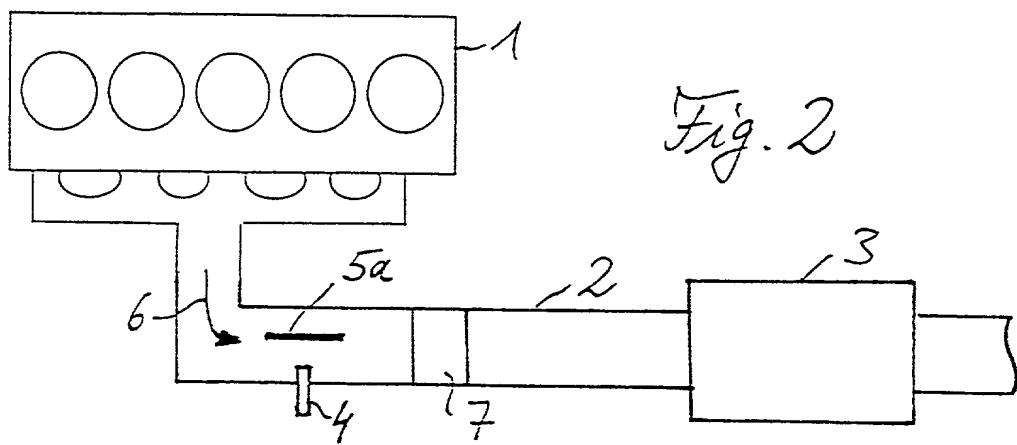
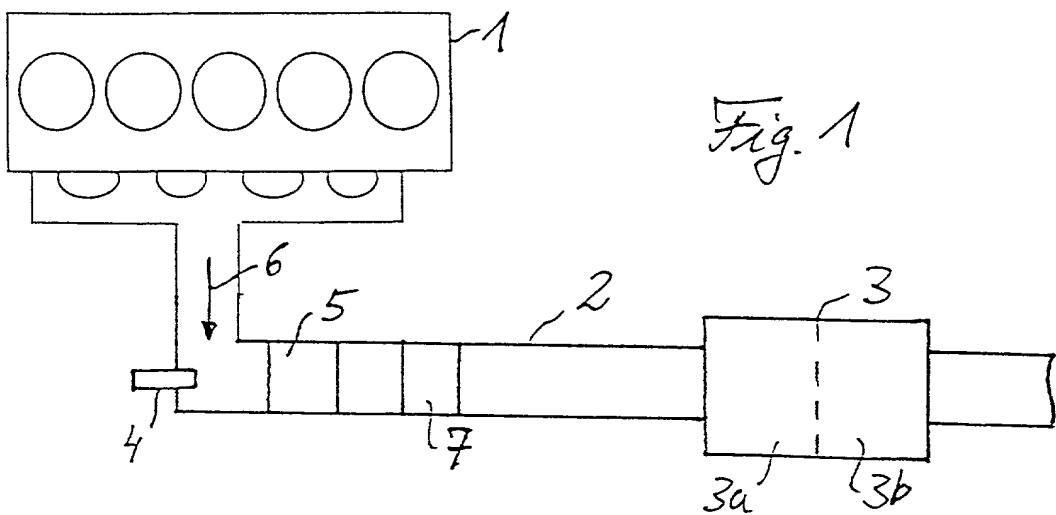
wherein said vaporizing comprises heating the reducing  
agent by microwave radiation or by spraying the reducing agent  
onto a heated deflector surface.

25 8. A method according to Claim 7, wherein said vaporizing  
further comprises hydrolysing urea to form gaseous ammonia and  
carbon monoxide.

9. A method according to Claim 7, wherein said heated  
deflector surface further comprises a catalytically active  
coating.

## **ABSTRACT**

An exhaust-gas cleaning system includes a nitrogen oxide reduction catalytic converter for reducing nitrogen oxides which are contained in the exhaust gas. A reducing agent is introduced into the exhaust-gas flow and is in the form of a vapour. A reducing-agent metering device for the metered addition of the reducing agent or a reducing-agent precursor to the exhaust-gas flow includes a vaporizer, which is arranged in the exhaust system upstream of the nitrogen oxide reduction catalytic converter. As a heat source, the vaporizer has (1) a heatable deflector surface, onto which the reducing agent, which is supplied by a feed unit, is directed under pressure; or (2) a microwave generator.



**DECLARATION AND POWER OF ATTORNEY - PATENT APPLICATION**

As a below named inventor, I hereby declare that my citizenship, postal address and residence are as stated below; that I verily believe I am the original, first and sole inventor (if only one inventor is named below) or a joint inventor (if plural inventors are named below) of the invention entitled:

**EXHAUST-GAS CLEANING SYSTEM WITH NITROGEN OXIDE REDUCTION  
AND WITH THE ADDITION OF REDUCING AGENT**

the specification of which

X is attached hereto, or

\_\_\_\_\_ was filed on \_\_\_\_\_ as Application Serial No. \_\_\_\_\_ and  
was amended on \_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose all information known to be material to patentability as defined in 37 CFR §1.56. I hereby claim foreign priority benefits under Title 35, United States Code §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

| Prior Foreign Application(s)       | Priority Claimed            |   |            |
|------------------------------------|-----------------------------|---|------------|
| <u>199 22 959.7-43</u><br>(Number) | <u>Germany</u><br>(Country) | <u>May 19, 1999</u><br>(Day/Month/Year) | <u>Yes</u> |

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose all information known to be material to patentability as defined in 37 CFR §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

|                                 |                      |                 |
|---------------------------------|----------------------|-----------------|
| <u>(Application Serial No.)</u> | <u>(Filing Date)</u> | <u>(Status)</u> |
|---------------------------------|----------------------|-----------------|

I hereby appoint as principal attorneys Herbert I. Cantor, Reg. No. 24,392; James F. McKeown, Reg. No. 25,406; Donald D. Evenson, Reg. No. 26,160; Joseph D. Evans, Reg. No. 26,269; Gary R. Edwards, Reg. No. 31,824; and Jeffrey D. Sanok, Reg. No. 32,169, to prosecute and transact all business in the Patent and Trademark Office connected with this application and any related United States and international applications. Please direct all communications to:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are

**DECLARATION AND POWER OF ATTORNEY**Attorney Docket No. 225/48876

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punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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